Urban Security Project

Goal of Project:

To develop the modeling tools required to assess the response of an urban system to changes in the physical environment, socio-political setting, and the economy.

A “SimCity-like” software environment, but with underlying physics-based science models.

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Urban Security—
Vulnerability and Sustainability

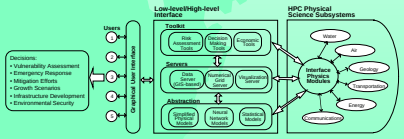
- Long-term goal: Develop a cross-divisional complex systems competency at LANL to assess the response of urban systems to changes in the physical environment, socio-political setting, and the economy.
- Why? To develop quantitative tools for long-range urban planning and risk assessment, to evaluate infrastructure vulnerability, and to test sustainability indicators

Urban Security—Vulnerability and Sustainability

- Infrastructure elements within cities are coupled and non-linear feedback mechanisms exist
  - *Sustainability* requires understanding the effects of planning decisions on the infrastructure elements (e.g., air and water pollution limit infrastructure growth)
  - *Vulnerability* to a given event (natural or technological) has ramifications across infrastructure elements (e.g., an earthquake affects telecommunications which limit ability to respond)

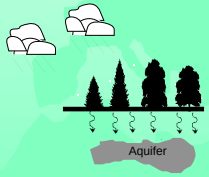
Urban Security - Research Tasks

Architecture Framework



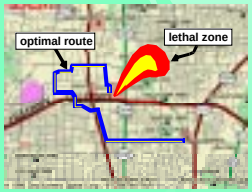
- high performance computing
- simplified physical models
- database issues
- end-user/GUI requirements

Coupled Atmospheric and Hydrologic Modeling



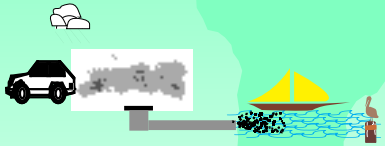
- precipitation modeled for dry and wet month
- impact on aquifer recharge

Airborne Toxic Release/ Emergency Response



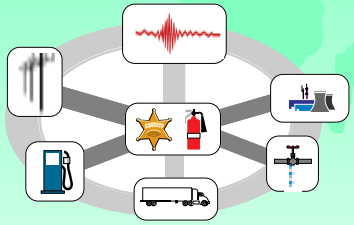
- multiscale plume simulations
- microscale traffic simulation

Urban Pollution Air-Water Pathways



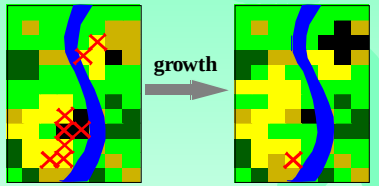
- linking air and water quality models through urban system

Infrastructure Damage from Natural Disasters



- earthquake modeling & damage

City Growth Modeling



- cellular automata method
- fn. of landuse, demographics, etc.

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Task 1 - Architecture Framework

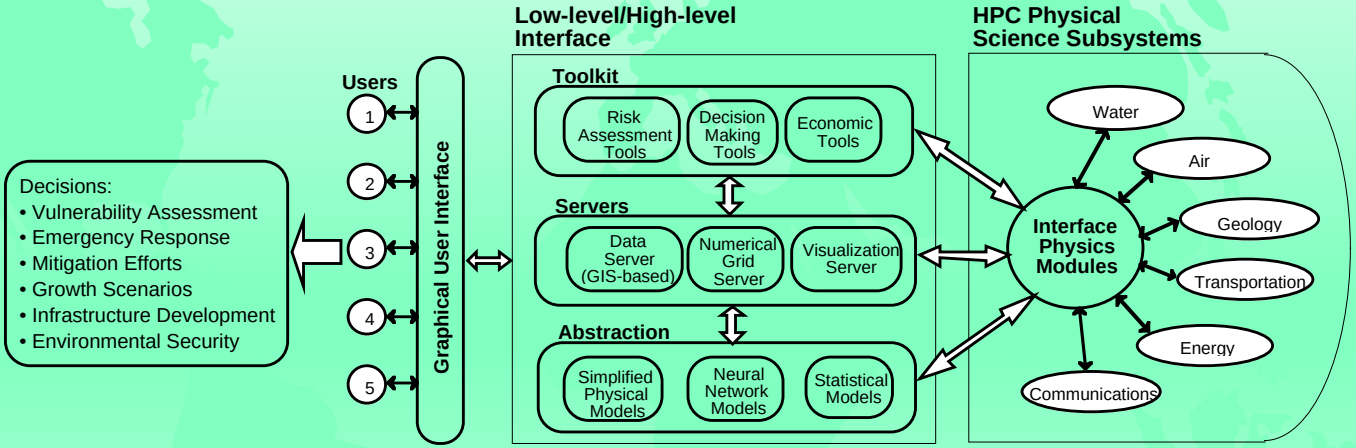

Figure 1. Schematic of proposed system architecture for answering urban security questions. Sophisticated numerical models from across disciplines and covering a broad range of scales will be integrated through interface physics modules. Methods for abstracting the "essential" physics will be utilized to speed computations and generalize results. Links between the physics-based models will be made to decision-making tools. Servers will provide data and visualization tools to the end-user.

Task 2 - Coupled Atmospheric & Hydrologic Modeling

Figure 2. We are investigating the impact of global change on the Albuquerque water supply using the Regional Atmospheric Modeling System and the Finite Element Heat and Mass transport model. Precipitation over the Rio Grande River basin was simulated for a wet and dry month. The spatially and temporally varying precipitation will then be input into the groundwater model to simulate aquifer recharge.

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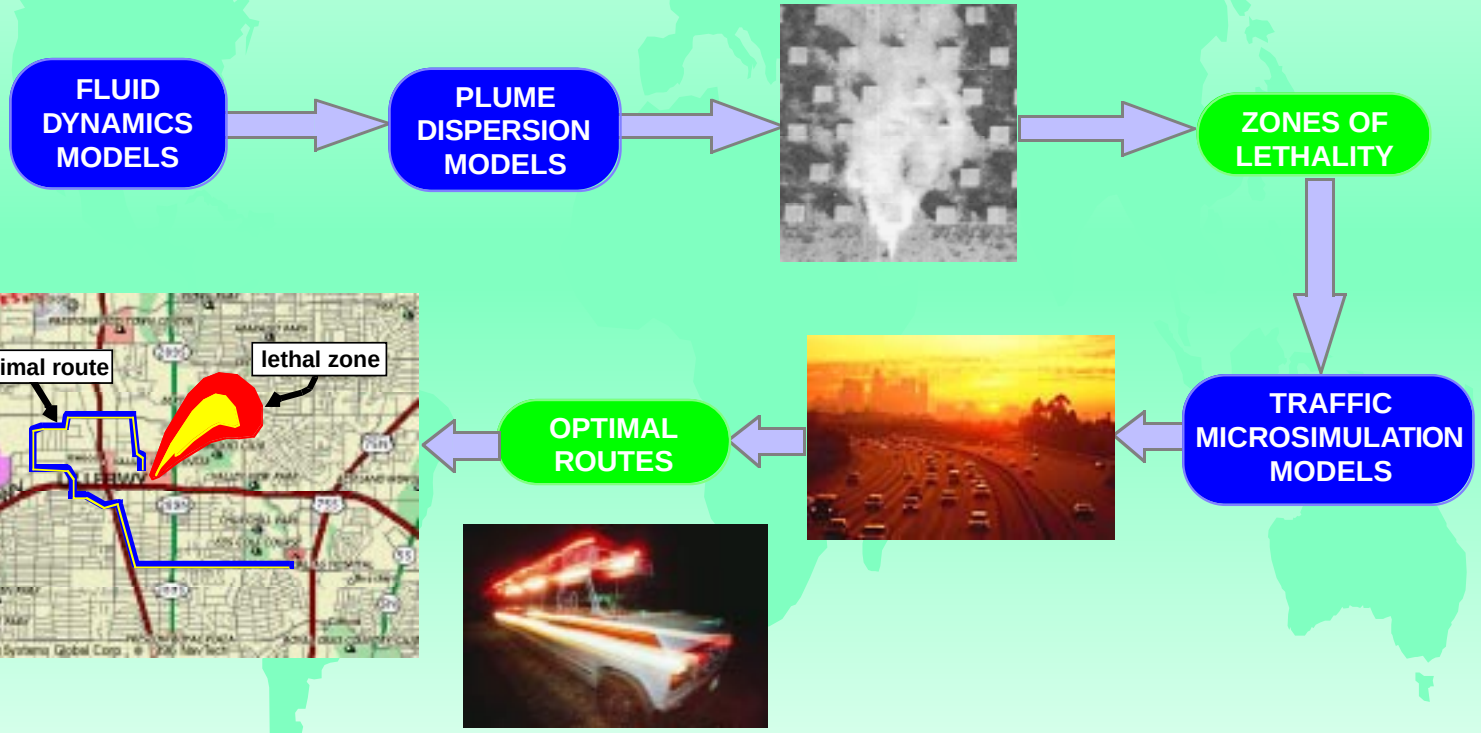
Task 3 - Airborne Toxic Release/Emergency Response



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Task 4 - Transportation-Air-Water Systems

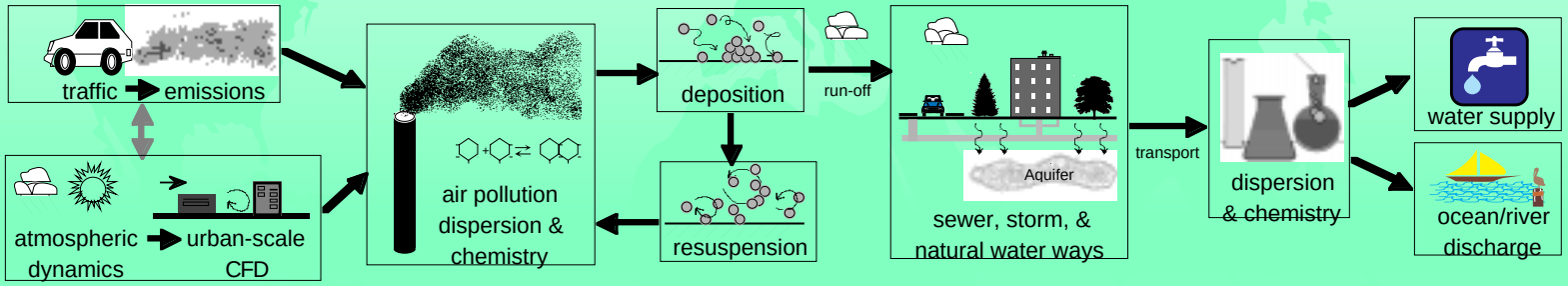

Figure 2. Nitrate pathway through the transportation, air, and water systems. The proposed modeling system can be applied to many different kinds of air contaminants (e.g., from accidental spills, industrial sources, a CBW attack). The air/water modules could be used in reverse to track vapors emanating from underground sources, as in many EM clean-up projects.

Task 5 - Infrastructure Damage from Natural Disasters

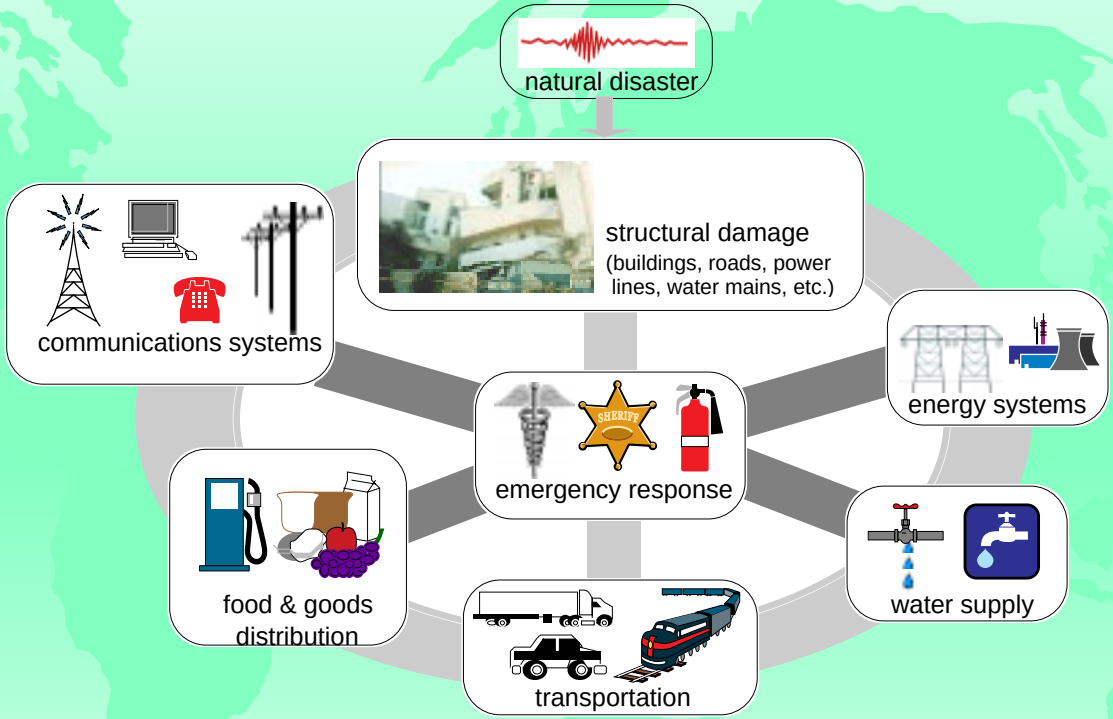

Figure 5. Earthquake disaster scenario linking structural damage, transportation, communication, water, and energy systems. The proposed modeling system could have military, sustainable growth, and infrastructure assessment applications as well.

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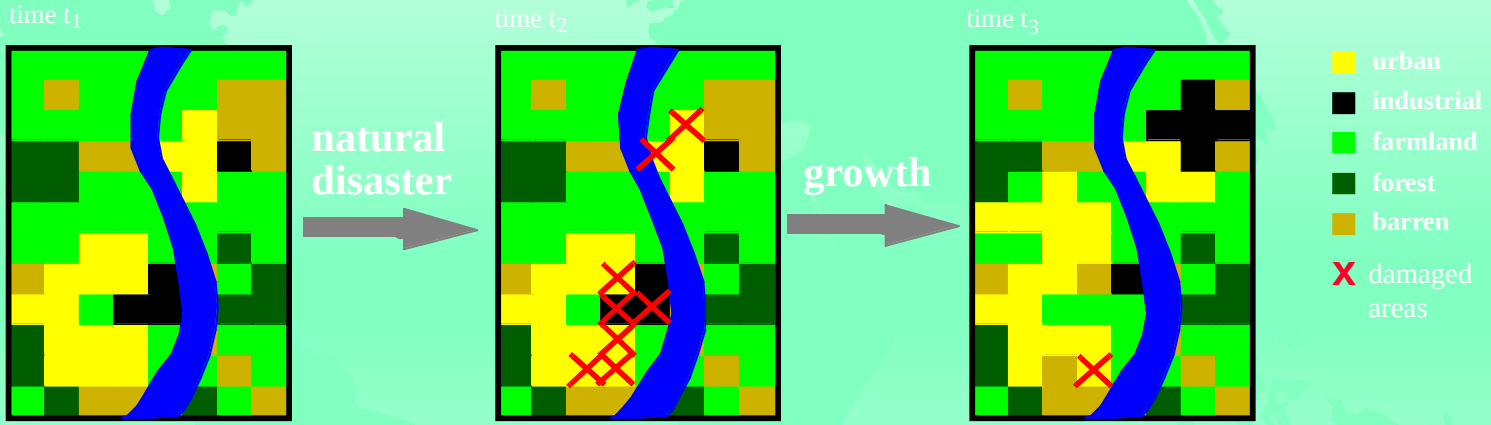
Task 6 - City Growth Modeling



Roger White's
Cellular Automata Model

Figure 6. We will evaluate how a city grows after an earthquake damages vulnerable sectors of the city. The city growth model uses cellular automatata methods, such that land conversion is based on simple rules involving land use, demographics, soil type, and economic indicators.

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Urban Security—Vulnerability and Sustainability

- 1997 Los Alamos Pilot Project
  - Developing tools for integration of environmental and urban processes, using high-performance computing platforms
  - Quantifying short-term environmental effects—dispersion and remediation of pollutants in an urban setting
  - Long-term urban environmental problems—integrate climate effects, surface water, and ground water models for the Albuquerque basin

Urban Security—
Vulnerability and Sustainability

- Pilot Project team:
  - Team members in the atmospheric sciences, environmental engineering and geology, ecology, software design, natural hazards, mathematics, hydrology, civil engineering, and urban planning

Urban Security—Vulnerability and Sustainability

- 1997 Los Alamos Pilot Project (continued)
  - Develop collaborations with urban planners and environmental scientists in universities, government, development banks, and industry
  - Establish the “road map” for data-based, interfaced city models
  - Choose specific cities to be used to develop and test the modeling tools

Urban Security—Vulnerability and Sustainability

- Progress during the first 6 months:
  - Papers on water supply issues and on air contaminant transport accepted for international conferences.
  - Existing atmospheric, hydrologic, and GIS capabilities stretched for urban applications.
  - Design criteria established for coupled models, using the ASCI HPC platform
  - Team members on IUGG megacities committee
  - Collaborations (DOE and UC)

Size of the Largest World Cities, 1985

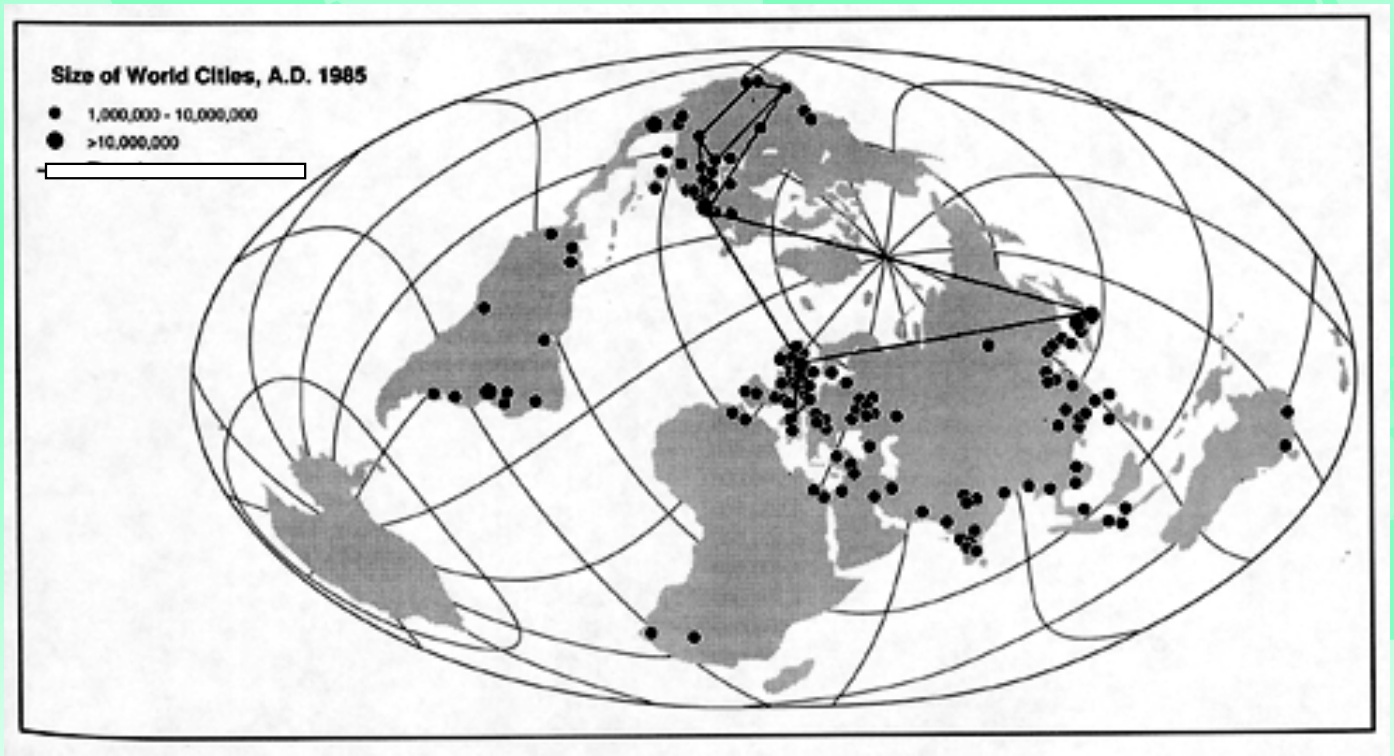

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Table 2 **List of urban agglomerations of 8 million or more persons by development region: 1950, 1970, 1990, and 2000**

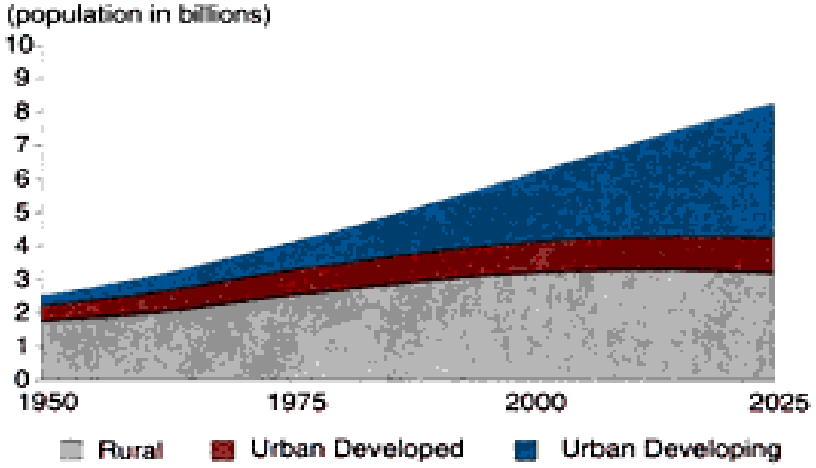
More developed regions

1950	1970	1990	2000
New York	New York	New York	New York
London	London	Tokyo	Tokyo
	Tokyo	Los Angeles	Los Angeles
	Los Angeles	Paris	Paris
	Paris	Moscow	Moscow
		Osaka	Osaka

Less developed regions

1950	1970	1990	2000
None	Mexico City	Mexico City	Mexico City
	São Paulo	São Paulo	São paulo
	Shanghai	Shanghai	Shanghai
	Beijing	Beijing	Beijing
	Buenos Aires	Buenos Aires	Buenos Aires
		Calcutta	Calcutta
		Bombay	Bombay
		Jakarta	Jakarta
		Delhi	Delhi
		Tianjin	Tianjin
		Seoul	Seoul
		Rio de Janeiro	Rio de Janeiro
		Cairo	Cairo
		Manila	Manila
			Lagos
			Dacca
			Karachi
			Bangkok
			Istanbul
			Teheran
			Bangalore
			Lima

Figure 1.1 Urban Population Growth, 1950–2025



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